

SHORT BUNCHES PERFORMANCE
WITH INTRABEAM SCATTERING

A.G. Ruggiero

(BNL, November 17, 1983)

Short Bunches

$$L = \frac{N_c^2 B \text{ freq}}{2\pi \alpha \sigma_e \sigma_v}$$

$$\sigma_e = 10 \text{ cm}$$

$$\text{freq} = 78.1973 \text{ kHz}$$

$$\sigma_v = 0.0037 \text{ cm}$$

$$N_c = 6.24 \times 10^8$$

$$\alpha = 4 \text{ mrad}$$

$$B = 57$$

$$L = 1.9 \times 10^{27} \text{ cm}^{-2} \text{ s}^{-1}$$

Filling sequence :

- one AGS pulse is made of 3 bunches
- 19 AGS pulses stacked in a box-car fashion

Filling Time : about 1 minute -

(2)

Longitudinal Stability of short bunches

$$|Z_n| = \frac{E/m}{eI_p} \left(2 \frac{\sigma_E}{\sigma_c}\right)^2 \frac{A}{Z^2}$$

$$I_p, \text{ peak current} = N_c e \beta_c / (\sigma_c \sqrt{2\pi})$$

$$N_c, \text{ no. of particles / bunch} = \cancel{6.24} \times 10^8$$

$$\sigma_c, \text{ rms bunch length} = 10 \text{ cm} \quad (\sigma_z = 0.33 \text{ ns})$$

$$I_p = 0.12 \text{ Amp-particle} \quad (\beta \approx 1)$$

$$\text{For Gold (Au)} \quad A = 197 \quad \text{and} \quad Z = 79$$

$$\text{Assume a coupling impedance of } |Z_n| = 10 \text{ ohm}$$

$$E, \text{ energy per nucleon} \sim 100 \text{ GeV/A}$$

$$\gamma = \gamma^{-2} - \gamma_T^{-2}, \quad \gamma_T = \text{transition energy / rest energy}$$

$$\sigma_E/E, \text{ rms energy spread at stability}$$

$$B = 6\pi \sigma_E \cdot \sigma_c, \text{ bunch area}$$

The following table explores the dependence on γ_T of the threshold energy spread σ_E/E and the corresponding bunch area -

(3)

δ_T	$ \eta $	σ_E/E threshold @ 100 GeV/A	B eV/A - sec
10	.0099	0.98×10^{-4}	0.061
20	.0024	1.99×10^{-4}	0.124
30	1.011×10^{-3}	3.07×10^{-4}	0.191
50	3×10^{-4}	5.63×10^{-4}	0.350
80	5.625×10^{-5}	13.00×10^{-4}	0.809

Intrabeam scattering diffusion rates @ 100 GeV/A

$$E_N = 4.0 \pi \text{ mm.mrad}$$

σ_E/E	t_E	t_β
1×10^{-4}	0.13 hours	0.32 hours
2×10^{-4}	0.68	0.43
4×10^{-4}	4.4	0.7

(4)

At injection ($12 \text{ GeV}/\text{A}$) we keep the same σ_e/G but lengthen the bunch by a factor $100/12 = 8.333$ then the peak current at injection is

$$I_p = 0.014 \text{ Amp-particle} \quad (\beta \sim 1)$$

IntraBeam Scattering Diffusion Rates @ $12 \text{ GeV}/\text{A}$

$$\epsilon_N = 4.0 \pi \text{ mm-mrad}$$

σ_e/G	t_e	t_β
$1. \times 10^{-4}$	0.057 hours	5.5 hours
2.	0.37	8.8
4.	4.0	24.
8.	350.	700.